

## Description

# [A/D CONVERSION PHASE ADJUSTING METHOD]

### CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the priority benefit of Taiwan application serial no. 92113043, filed May 14, 2003.

### BACKGROUND OF INVENTION

[0002] Field of the invention

[0003] The present invention pertains to a phase adjusting method of an analog-to-digital (A/D) video signal conversion in general, and more particularly to an optimized phase detecting method based on a plurality of video frames to adjust an A/D video signal conversion.

[0004] Description of the Related Art

[0005] In these modern times, as a use of a computer video system getting popular, how to display data precisely on a display device becomes an important issue for the industry. Currently, according to an input video signal, display

devices can be grouped into two categories; one receiving an analog video signal is an analog-input video display device, and the other receiving a digital video signal is a digital-input video display device. Due to a cost issue and a relatively limited application support, the digital-input video display device is not yet as popular as the analog-input video display device in most circumstances. Therefore, the analog-input video display device is most commonly used in a computer video system.

[0006] According to a displaying image method, the analog-input video display device can be further grouped into two categories; one display device uses an analog-output display method, and the other display device uses a digital-output display method. For improving an image color resolution ability, more and more display devices use the digital-output display method instead of using the analog-output display method. However, to an analog-input and digital-output display device, internally an A/D converter must be used to convert an input analog video signal to an output digital video signal to be able to be displayed on the display device.

[0007] Further, during an A/D conversion of a video signal, a choice of a display phase is critical to display quality of

the analog-input and digital-output display device. Based on a single video frame, a current A/D display technology calculates a phase characteristic function; and based on the phase characteristic function, a phase for an A/D conversion is obtained. Surely, to calculate the phase characteristic function based on a single video frame is a way to obtain a phase required in an A/D video signal conversion, but there is no prove to indicate that the phase characteristic function is a better way to obtain a phase in A/D video signal conversion. In other words, in the current A/D video display technology, a better way to choose a phase during an A/D video signal conversion is still not yet defined.

#### **SUMMARY OF INVENTION**

[0008] Accordingly, one preferred embodiment of the present invention provides a phase adjusting method of an A/D video signal conversion that effectively chooses a better phase for the A/D video signal conversion.

[0009] The preferred embodiment of the present invention also provides a phase adjusting method of an A/D video signal conversion that a phase in A/D video signal conversion is determined according to a relationship among adjacent video frames.

[0010] The preferred embodiment of the present invention also provides a phase adjusting method of an A/D video signal conversion that provides a stable display quality to a static image display.

[0011] The preferred embodiment of the present invention provides a phase adjusting method for an A/D video signal conversion. The phase adjusting method first collects a set of phases. Then, each phase in the set is applied to convert a plurality of analog video frames to corresponding digital frames. Next, a number of differences between a plurality of predetermined corresponding pixels in two digital frames are calculated, and absolute values of the differences are added up to obtain a sum of an absolute display difference. After all the phases in the set are applied to analog video frames, and after obtaining all absolute display differences of the phases in the set, a phase that provides a smallest absolute display difference is chosen to convert a following analog video frames to their corresponding digital frames.

[0012] In a preferred embodiment of the present invention, pixels at a center and four corners of a frame are chosen to calculate an absolute display difference between digital frames. Moreover, instead of calculating the smallest ab-

solute display difference from the set of phases, a moving average calculation method can be also applied to the set of phases and video frames to obtain a phase that causes a smallest moving average. As a result, the phase producing the smallest moving average is chosen to be a base to convert an analog video signal to a digital video signal.

[0013] The preferred embodiment of the present invention further provides a phase adjusting method for an A/D video signal conversion where a phase reference is preset firstly. Then, the phase reference is applied to convert a first analog video frame to a first digital video frame, and a second analog video frame to a second digital video frame. Next, the phase adjusting method chooses a plurality of pixels from the first digital frame and, at same positions, chooses a plurality of pixels from the second digital frame. An absolute display difference is obtained by adding up an absolute difference between two pixels at a frame position of the two digital frames all over the positions where the pixels are chosen. Next, the phase reference is changed to another value, and the same procedure described above is applied, as a consequence, a new absolute display difference is obtained accordingly. After several trials, a phase reference producing a smallest ab-

solute display difference is chosen to perform a following A/D video signal conversion.

[0014] The embodiment of the present invention uses relationship between two digital frames to obtain a phase characteristic function and a curve of digital frames. Further, with the phase characteristic function and the curve, a phase causing a smallest difference between two digital frames is obtained. Accordingly, a preferred embodiment of the present invention provides a static dominant display application, such as a computer or a projector application, to have a stable display quality.

#### **BRIEF DESCRIPTION OF DRAWINGS**

[0015] The accompanying drawings are included to provide a further understanding of the invention, and are incorporated in and constitute a part of this specification. The drawings illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention. The drawings are as follows.

[0016] FIG. 1 demonstrates an image processing apparatus in a block diagram that is commonly used in a display apparatus with analog video input.

[0017] FIG. 2 depicts the steps of the phase adjusting method of a preferred embodiment of the present invention in a

flow-chart diagram.

[0018] FIG. 3 depicts that pixels are chosen from two digital frames in the preferred embodiment of the present invention.

[0019] FIG. 4A and FIG. 4B depicts an absolute display difference curve that is produced according to the preferred embodiment of the present invention.

[0020] FIG. 5 depicts the steps of the phase adjusting method of another preferred embodiment of the present invention in a flow-chart diagram.

#### **DETAILED DESCRIPTION**

[0021] Reference will now be made in detail to the present preferred embodiments of the invention, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers are used in the drawings and the description to refer to the same or like parts.

[0022] For allowing those skilled in the art to understand the invention easily, before introducing a phase adjusting method of the embodiment of the invention, a hardware structure for the method is first introduced as follows. Referring to *FIG. 1*, a commonly used image processing apparatus with analog video input is depicted in a block dia-

gram. In the figure, an image processing apparatus *10* receives an analog video signal including a vertical synchronization (V-sync) signal, a horizontal synchronization (H-sync) signal, a red (R) signal, a green (G) signal, and a blue (B) signal from a host (not shown in figures). Wherein the analog video signal is converted to a digital video signal prior to display on a digital display panel *12*.

[0023] The image processing apparatus *10* comprises an A/D converter *102*, a scaler *104*, a microcontroller *106*, a memory *108*, and a frame buffer memory *110*. An analog video signal received via the image processing apparatus *10* is first converted to a digital video signal by the A/D converter *102* before sending to the scaler *104*. The scaler *104* temporarily stores the digital video signal to the frame buffer memory *110*, and according to a preset value in the image processing apparatus enlarges or shrinks a digital image contained in the digital video signal to fit on the digital display device *12*. The micro-controller *106* and the memory *108* are used to execute and store a program and data doing the tasks described above.

[0024] A phase setting in the A/D converter *102* is critical to obtain a clear and stable image display. In other words, an improper phase setting causes a fuzzy image display,

whereas a better phase setting brings a clear and sharp image display on the display device. The preferred embodiment of the present invention provides a method to obtain a better phase setting to optimize an image display.

[0025] Referring to *FIG. 2*, a procedure of performing a preferred embodiment of the present invention is demonstrated in a flow-chart diagram. In the preferred embodiment of the present invention, a preset phase reference is first determined in step *S200*. Then, the preset phase reference is applied to convert a first analog video frame and a second analog video frame to a first digital video frame and a second digital video frame. In step *S202*, a plurality of pixels are picked up from the first digital video frame, and at the same positions, the corresponding pixels are picking from the second digital video frame. As depicted in *FIG. 3*, and as an example, digital video frames *30*, *35* represents the first digital video frame and the second digital frame, and are converted from a pair of analog video frames based on the same phase reference. It is noted that a pixel *302* in the first video frame *30* and a pixel *352* in the second video frame *35* are at a same frame position. Similarly, pixels *304*, *306*, *308*, *310* in the first video frame *30*

and pixels 354, 356, 358, 360 in the second video frame 35 are at same frame positions respectively. It is also noted that in the example, positions of four corners and a center of a frame are chosen for the pixels to pick up from. However, the number of pixels and the positions where the pixels are chosen from are flexible and are based on a need of an exercise of the preferred embodiment of the present invention.

[0026] Next, in step *S204*, an absolute difference between two pixels from a position in the first and the second digital video frames is calculated. For example, in *FIG. 3*, an absolute difference between pixels from a position is an absolute difference of RGB display values of pixels 302, 352. In step *S206*, a summation of all absolute difference between pixels from all positions is calculated to obtain an absolute display difference between two digital video frames. For example, in *FIG. 3*, an absolute display difference between two digital video frames is obtained by adding up absolute differences between display values of pixels 302, 352, pixels 304, 354, pixels 306, 356, pixels 308, 358, and pixels 310, 360.

[0027] Step *S208* provides a testing mechanism to test out if all target phase references are applied to convert analog

video frames. If the answer is negative, the method picks up a not yet applied phase reference and jumps to step *S200*, and steps *S200* to *S206* are executed accordingly. After all the target phase references are applied to convert analog video frames, and all the absolute display differences are obtained, a smallest absolute display difference is picked up. In step *S210*, a phase reference resulting in the smallest absolute display difference is applied to a following A/D converting task.

[0028] In a preferred embodiment of the present invention, in step *S210*, a moving average method is applied to the absolute display differences to obtain a moving average curve. Referring to *FIG. 4A*, thirty-two phase references (0 to 31) are applied to a sequence of analog video frames to obtain thirty-two absolute display differences, and the absolute display differences are depicted in *FIG. 4A*.

[0029] In *FIG. 4A*, the rhombus points in curve  $F_c$  represent the absolute display differences, and after apply the moving average method to the absolute display differences, the curve  $F_{c\_ma}$  comprises square points is obtained. Referring to *FIG. 4A* herein. In the curve  $F_c$ , the twentieth rhombus point is the lowest point in the curve, thus its corresponding phase reference is chosen to perform an A/D conver-

sion. Whereas in the curve  $F_{c\_ma}$ , the nineteenth square point is the lowest point in the curve, thus its corresponding phase reference is chosen to perform an A/D conversion. It is clear that the results from the two curves are similar and display qualities of these two-phase references are almost identical. To those skilled in the art, based on different circumstances, results from the moving average method or directly from the absolute display differences can be used to meet their needs.

[0030] To save time on picking up a better phase reference, in a preferred embodiment of the present invention, a better phase reference is picked up from a reduced set of phase references. In *FIG. 4B*, a phase reference is only picked up from an odd number position of the set of the phase references, so that a half time is saved comparing with the results from *FIG. 4A*. Clearly, since the number of the phase references is reduced, accuracy in picking up the smallest absolute display difference is reduced as well. For example, in *FIG. 4B*, by following curve  $F_c$ , the smallest absolute display difference is at the seventeenth phase reference; however, by following curve  $F_{c\_ma}$ , the smallest absolute display difference is at the nineteenth phase reference. In practice, a user can pick up

either one to meet the user's need. Basically, a minor difference between two phase references results in a minor difference of display resolutions.

[0031] Moreover, before a video frame is obtained, writing a video frame to a frame buffer, for instance the frame buffer memory 110 in *FIG. 1*, causes a delay, and an A/D conversion also takes time. To save time in obtaining a better phase reference, consecutive video frames are used to calculate an absolute display difference, and a number of video frames are reduced for a phase reference. Referring to *FIG. 5*, steps of the phase adjusting method of a preferred embodiment of the present invention are demonstrated in a flow-chart diagram. In *FIG. 5*, the method first picks up a phase reference from a set of phase references in step *S500*. In step *S502*, the phase reference is applied to convert a plurality of analog video frames to a plurality of digital video frames. Then, at same frame positions, a number of corresponding pixels are chosen from each of the digital video frames in step *S504*. An absolute display difference is calculated in step *S506*. Next, in step *S508*, a test procedure is taken to determine if all the phase references in the set of phase references have been applied to convert analog video frames. Steps

*S500* to *S506* are repeated if a phase reference is found not yet applied to convert an analog video frame. If all the phase references in the set are applied to convert analog video frames, in step *S510*, a phase reference producing a smallest absolute display difference is used to convert a following analog video frame.

[0032] Similar to above description, the moving average method can be applied to the absolute display differences found in *S510* so as to obtain a curve and thus a phase reference that causes a lowest point in the curve.

[0033] As a summary to the above description, the preferred embodiment of the present invention provides a phase adjusting method in which a number of phase references are applied to convert a number of analog video frames. After the conversion, absolute display differences are calculated; thereby, a phase reference produces a smallest absolute display difference is picked up to convert a following analog video frame. By applying the preferred embodiment of the present invention to a computer image display or a projector image display, a clear and high-resolution display is easily obtained.

[0034] It will be apparent to those skilled in the art that various modifications and variations can be made to the structure

or to the methods of the preferred embodiment of the present invention without departing from the scope or spirit of the invention. In view of the foregoing, it is intended that the present invention cover modifications and variations of this invention provided they fall within the scope of the following claims and their equivalents.